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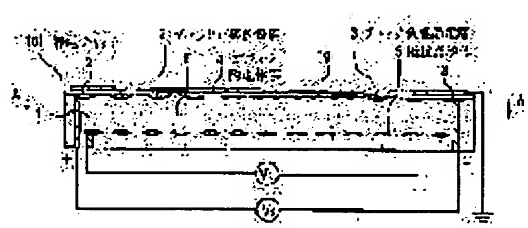
ITO YASUTAKA

(54) CERAMIC SUBSTRATE AND MANUFACTURING METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a ceramic substrate which has superior heat distribution and heat shock resistance and provides a high chuck power when used as an electrostatic chuck.

SOLUTION: A ceramic substrate consisting of a conductor layer formed inside is characterized by that a section of an end of the conductor layer is sharply pointed.



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CLAIMS

[Claim(s)]
[Claim 1] It is the ceramic substrate characterized by the cross section of the edge of said conductor layer being the cusp-like in the ceramic substrate which comes to form a conductor layer in the interior of a ceramic substrate.
[Claim 2] Said conductor layer is a ceramic substrate according to claim 1 which is a resistance heating element and functions as a hot plate.
[Claim 3] Said conductor layer is a ceramic substrate according to claim 1 or 2 which is an electrostatic electrode and functions as an electrostatic chuck.
[Claim 4] Said conductor layer is a ceramic substrate given in any 1 of claims 1-3 which have the cusp-like section with a width of face of 0.1-200 micrometers.
[Claim 5] The manufacture approach of the ceramic substrate characterized by printing a conductor layer to a ceramic green sheet, pressurizing and unifying, heating with another green sheet, and subsequently making a ceramic sinter.

[Translation done.]

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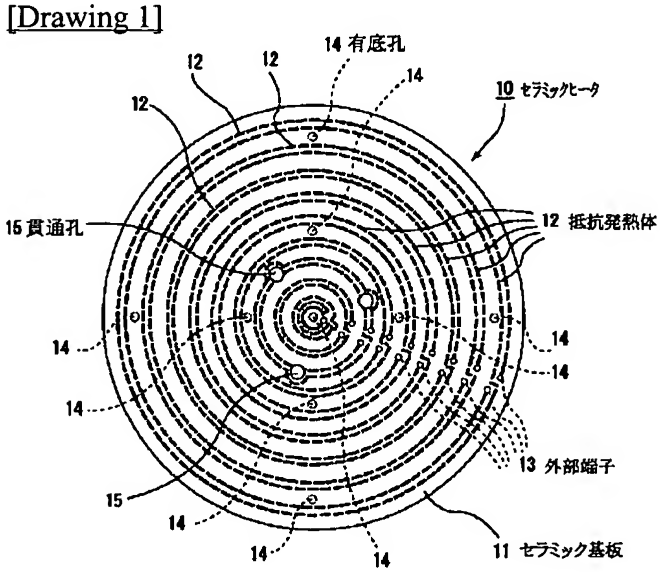
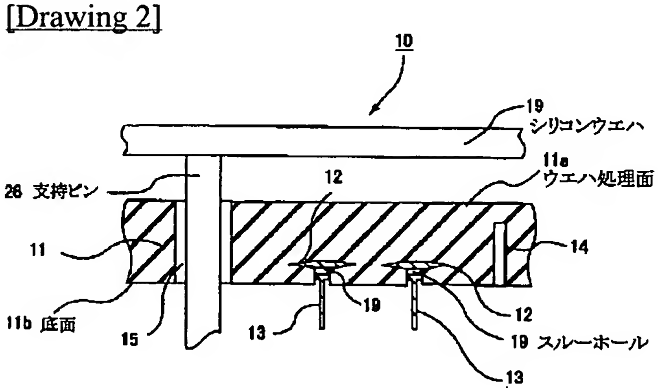
DRAWINGS

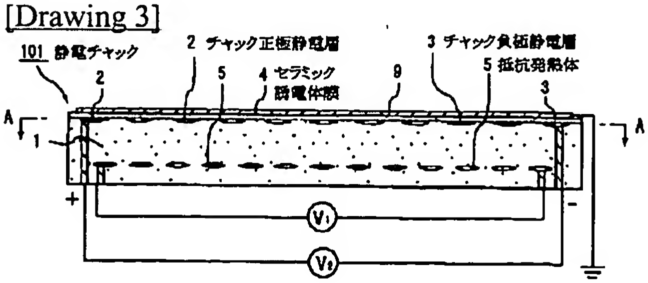
[Drawing 1]



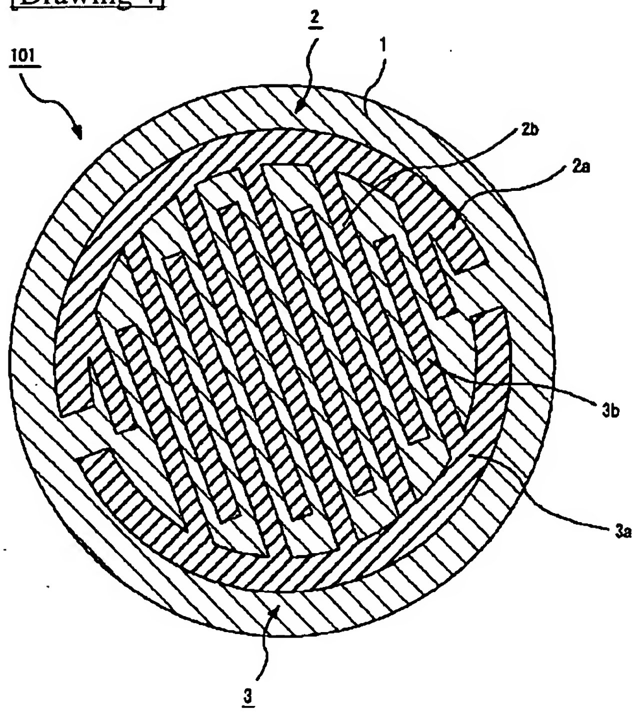
[Drawing 2]



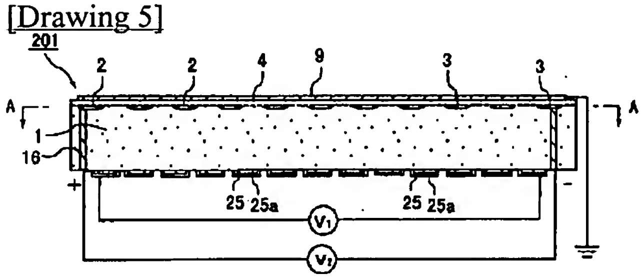
[Drawing 3]



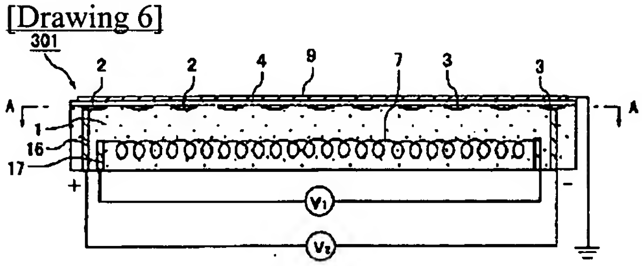
[Drawing 4]



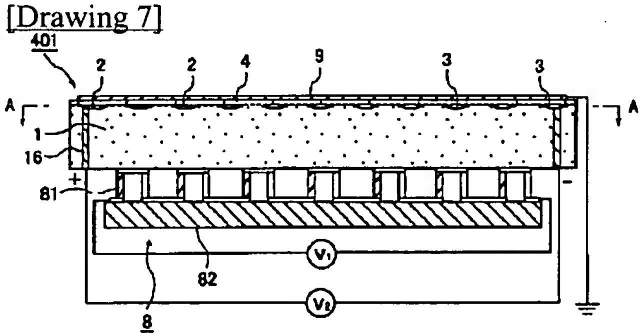
[Drawing 5]



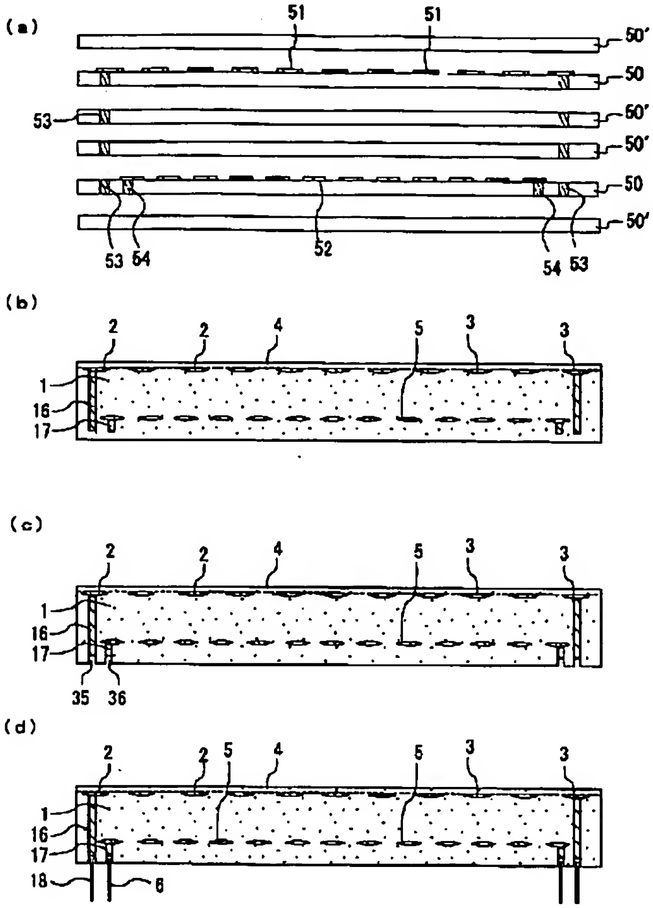
[Drawing 6]



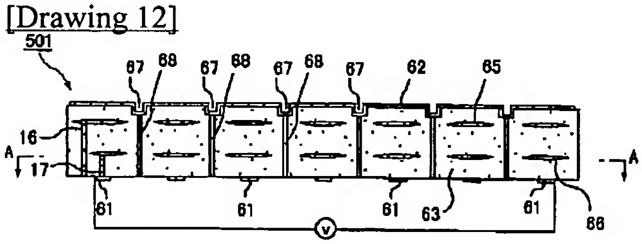
[Drawing 7]



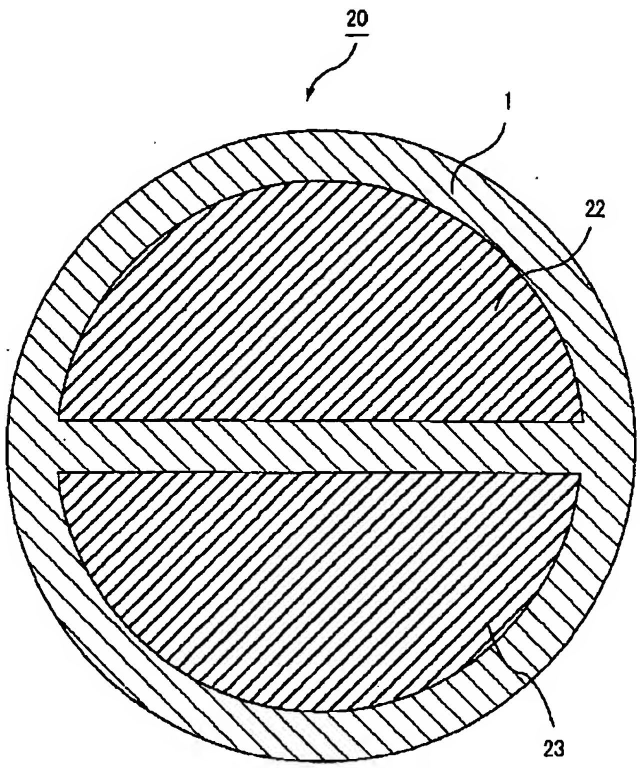
[Drawing 8]



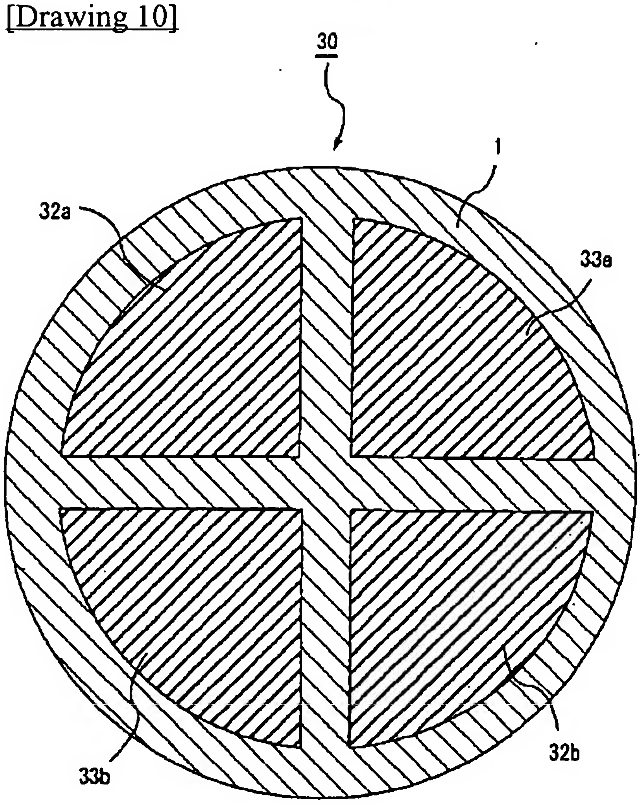
[Drawing 12]



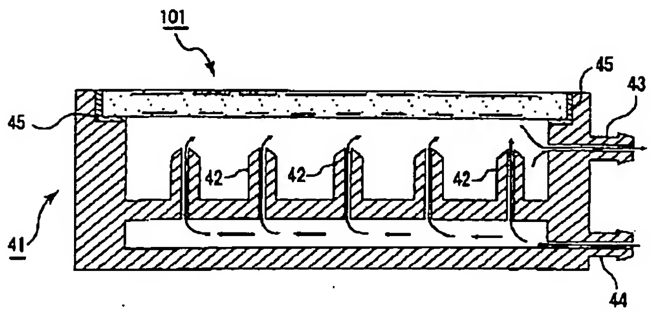
[Drawing 9]



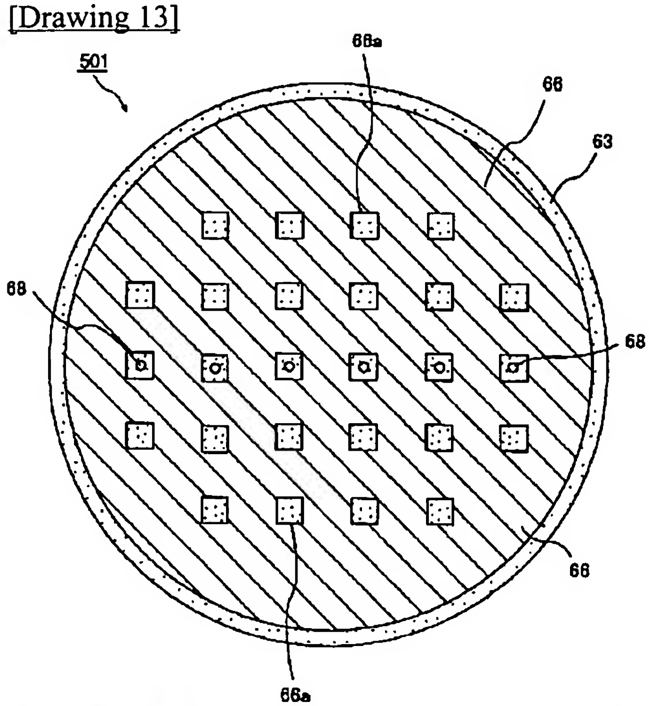
[Drawing 10]



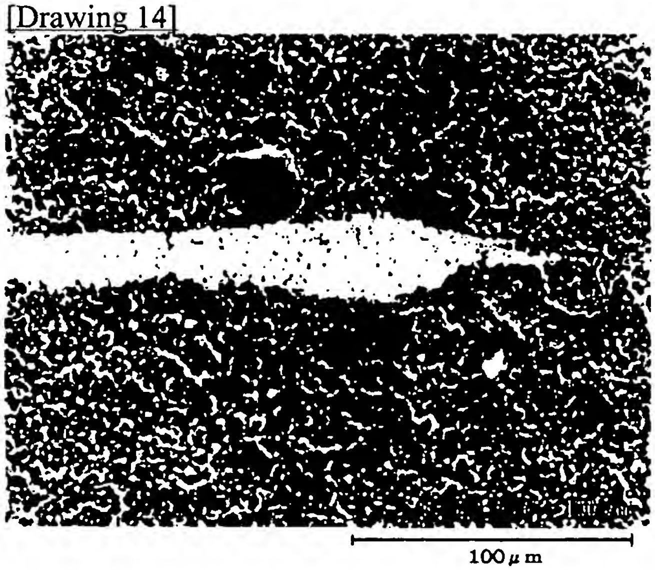
[Drawing 11]



[Drawing 13]



[Drawing 14]



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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the top view showing typically an example of the ceramic heater using the ceramic substrate of this invention.
[Drawing 2] It is the partial expanded sectional view of the ceramic heater shown in drawing 1 .
[Drawing 3] It is the sectional view showing typically an example of the electrostatic chuck using the ceramic substrate of this invention.
[Drawing 4] It is the A-A line sectional view of a ceramic heater shown in drawing 3 .
[Drawing 5] It is the sectional view showing typically an example of the electrostatic chuck using the ceramic substrate of this invention.
[Drawing 6] It is the sectional view showing typically an example of the electrostatic chuck using the ceramic substrate of this invention.
[Drawing 7] It is the sectional view showing typically an example of the electrostatic chuck using the ceramic substrate of this invention.
[Drawing 8] (a) - (d) is the sectional view showing typically a part of production process of the electrostatic chuck shown in drawing 5 .
[Drawing 9] It is the horizontal sectional view having shown typically the configuration of the electrostatic electrode which constitutes the electrostatic chuck concerning this invention.
[Drawing 10] It is the horizontal sectional view having shown typically the configuration of the electrostatic electrode which constitutes the electrostatic chuck concerning this invention.
[Drawing 11] It is the sectional view having shown typically the condition of having inserted the electrostatic chuck concerning this invention in the support container.
[Drawing 12] It is the sectional view having shown typically the wafer prober using the ceramic substrate of this invention.
[Drawing 13] It is the sectional view having shown typically the guard electrodes of the wafer prober shown in drawing 12 .
[Drawing 14] It is the SEM photograph in which the destructive cross section of the ceramic substrate which constitutes the electrostatic chuck concerning an example 1 was shown.
[Description of Notations]
1, 11, 63 Ceramic substrate
2, 22, 32a, 32b Chuck positive-electrode electrostatic layer
3, 23, 33a, 33b Chuck negative-electrode electrostatic layer
2a, 3a Semicircle arc section
2b, 3b Ctenidium section
4 Ceramic Dielectric Film
5, 12, 25, 61 Resistance heating element
6, 13, 18 External terminal
7 Metal Wire
8 Peltier Device

9 Silicon Wafer
10 Ceramic Heater
14 Closed-end Hole
15 Through Tube
16, 17, 19 Through hole
20 30,101,201,301,401 Electrostatic chuck
25a Metallic-coating layer
35 36 Sac hole
41 Support Container
42 Refrigerant Diffuser
43 Inhalation Opening
44 Refrigerant Inlet
45 Heat Insulator
62 Chuck Top Conductor Layer
65 Guard Electrodes
66 Grand Electrode
66a Electrode agenesis field
67 Slot
68 Suction Hole
501 Wafer Prober

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] About the ceramic substrate mainly used in semiconductor industry, especially, this invention is suitable for a hot plate, an electrostatic chuck, a wafer prober, etc., and relates to the ceramic substrate excellent in thermal shock resistance, soak nature, the chuck force, etc.
[Detailed description]
[0002]
[Description of the Prior Art] A semi-conductor is a very important product needed in various industries, and a semiconductor chip is manufactured by forming two or more integrated circuits etc. in this silicon wafer, after slicing a silicon single crystal in predetermined thickness and producing a silicon wafer.
[0003] the silicon wafer laid on the electrostatic chuck in the production process of this semiconductor chip -- various processings of etching, CVD, etc. -- giving -- a conductor -- a circuit, a component, etc. are formed. Since it is necessary to protect an electrostatic electrode layer from the corrosion by these gas and in order to use corrosive gas as the gas for deposition, gas for etching, etc., and it is necessary to carry out induction of the adsorption power in that case, the electrostatic electrode layer is usually covered with the ceramic dielectric film etc. The electrostatic chuck with a heater which printed and carried out the laminating of the metal pastes, such as a tungsten (W), to the green sheet as this ceramic substrate at the patent printing official report No. 2798570, the patent printing official report No. 2513995, JP,11-74064,A, etc. is indicated.
[0004]
[Problem(s) to be Solved by the Invention] However, in the ceramic substrate manufactured by such approach, when the thermal shock was added, the crack occurred from the edge of conductor layers, such as a resistance heating element, or the heating element was met and the problem of an elevated-temperature field being generated occurred. Furthermore, dispersion arose also in the chuck force and sufficient adsorption power was not acquired. Moreover, about an internal electrode and an internal resistance heating element, the leakage current in the elevated temperature between an electrode or a resistance heating element poses a problem.
[0005]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, as a result of inquiring wholeheartedly, this invention persons are making into the shape of cusp the edge of the cross section of the conductor layer which constitutes an electrostatic electrode, RF electrode, and a resistance heating element, find out newly that these problems are solvable, and came to complete this invention.
[0006] That is, in the ceramic substrate to which, as for this invention, it comes to form a conductor layer inside a ceramic substrate, the cross section of the edge of the above-mentioned conductor layer is a ceramic substrate characterized by being the cusp-like.
[0007] In the ceramic substrate of this invention, when the above-mentioned conductor layer is a resistance heating element, it functions as a hot plate, and when the above-mentioned conductor layer is an electrostatic electrode, it functions as an electrostatic chuck. As for the ceramic substrate of this

invention, it is desirable to be used at the temperature of 150 degrees C or more, and it is most desirable to be used at the temperature of 200 degrees C or more.
[0008] Moreover, in the above-mentioned ceramic substrate, as for the above-mentioned conductor layer, it is desirable to have the cusp-like section with a width of face of 0.1-200 micrometers, and it is more desirable to have the cusp-like section of the width of face which is 5-100 micrometers. Moreover, in case the above-mentioned ceramic substrate is manufactured, it is desirable to take the approach of printing a conductor layer to a ceramic green sheet, pressurizing and unifying, heating with another green sheet, and subsequently making a ceramic sintering.
[0009] Since the edge of an electrode is the cusp-like when it is, an electrode, i.e., an electrostatic electrode, for the conductor layer laid under the ceramic substrate used by this invention to carry out induction of the chuck force of an electrostatic chuck, electric field concentrate along this edge and it is thought that the big chuck force is attracted.
[0010] Moreover, when it analyzes about the reason which a crack generates by the thermal shock, a cross section is a rectangle in general and the conductor layer manufactured using the conventional printing approach etc. has a field perpendicular to a wafer processing side (field to which a semi-conductor wafer is heated, and it holds and sticks). Moreover, the coefficients of thermal expansion of a conductor layer and the ceramic which constitutes a ceramic substrate differ. Therefore, if a ceramic substrate is heated or it is cooled, the force which pulls apart between fields and ceramics perpendicular to the wafer processing side of a conductor layer will be added, and it will be thought that it becomes easy to generate a crack for this force. However, in the ceramic substrate of this invention, since a field perpendicular to a wafer processing side does not exist in a conductor layer, it is hard to generate a crack.
[0011] Furthermore, it is thought that an elevated-temperature field will be generated along with a resistance heating element because the accumulation of the intersection part of a field level to a field perpendicular to the processing side of a wafer is easy to be carried out among resistance heating elements. Although the reason which such an accumulation phenomenon produces is not certain, emission propagation of the heat is carried out among resistance heating elements from both fields level to a field perpendicular to the processing side of a wafer, and it is presumed that it is because these heat crosses in an intersection part exactly. However, since a field perpendicular to a wafer processing side does not exist, it is not generated but such an accumulation phenomenon is excellent in the soak nature in a wafer processing side with the ceramic substrate of this invention. Furthermore, if a field perpendicular to the wafer processing side of a conductor layer exists when it has conductor layers, such as electrodes (the guard electrodes of a wafer prober, a grand electrode, the electrode of an electrostatic chuck, RF electrode, etc.), and a resistance heating element, inside a ceramic substrate, these fields will counter and it will become easy to generate the leakage current in an elevated temperature. In this invention, the edge cross section of a conductor layer has become cusp-like, and in order for fields not to counter, it is hard to generate the leakage current in an elevated temperature. 150 degrees C or more of ceramic substrates of this invention are desirably used in a temperature field 200 degrees C or more.
[0012] The conductor layer of **** of this invention is good at an electrostatic electrode, a resistance heating element, and RF electrode, and its **** is also good at the guard electrodes and the grand electrode which are used by the wafer prober.
[0013] As for the above-mentioned conductor layer, it is desirable to have the cusp-like section with a width of face of 0.1-200 micrometers. It is because dispersion will be produced in resistance and effectiveness, such as the above-mentioned crack prevention, on the other hand, will not occur that it is less than 0.1 micrometers, if the width of face of the above-mentioned cusp-like section exceeds 200 micrometers. Especially the width of face of the cusp-like section has optimal 5-100 micrometers. Moreover, the radius of curvature of the cusp-like section has optimal 0.5-500 micrometers.
[0014] It is desirable for the pore diameter of the maximum pore to be 50 micrometers or less in the ceramic substrate of this invention, and 5% or less of porosity is desirable. Moreover, when pore does not exist in the above-mentioned ceramic substrate at all or pore exists in it, as for the pore diameter of the maximum pore, it is desirable that it is 50 micrometers or less.

[0015] When the withstand voltage in an elevated temperature becomes especially high when pore does not exist, and pore exists conversely, a fracture toughness value becomes high. For this reason, which design it is made changes with demand characteristics. Although the reason a fracture toughness value becomes high by existence of pore is not clear, it is presumed that it is because progress of a crack is stopped by pore.
[0016] When, as for one with desirable the pore diameter of the maximum pore being 50 micrometers or less in this invention, a pore diameter exceeds 50 micrometers, it is because it becomes difficult an elevated temperature and to secure the withstand voltage property in 200 degrees C or more especially. The pore diameter of the maximum pore has desirable 10 micrometers or less. It is because the amount of curvatures in 200 degrees C or more becomes small.
[0017] Additives, such as pressurization time amount at the time of sintering, a pressure, temperature, SiC, and BN, adjust porosity and the pore diameter of the maximum pore. Since SiC and BN check sintering, they can make pore introduce.
[0018] In case the pore diameter of the maximum pore is measured, five samples are prepared, mirror polishing of the front face is carried out, and ten front faces are photoed by one 2000 to 5000 times the scale factor of this with an electron microscope. And the pore diameter greatest with the taken photograph is chosen, and let the average of 50 shots be the pore diameter of the maximum pore.
[0019] Porosity is measured by the Archimedes method. A sintered compact is ground, a grinding object is put in into an organic solvent or mercury, the volume is measured, it asks for true specific gravity from the weight and the volume of a grinding object, and porosity is calculated from true specific gravity and apparent specific gravity.
[0020] The diameter of the ceramic substrate of this invention has 200 desirablemm or more. It is desirable that it is especially 12 inch (300mm) more than. It is because it becomes in use [a next-generation semi-conductor wafer].
[0021] The thickness of the ceramic substrate of this invention has 50 desirablemm or less, and especially its 25mm or less is desirable. If the thickness of a ceramic substrate exceeds 25mm, the heat capacity of a ceramic substrate may be too large, and it is because it may originate in the magnitude of heat capacity and temperature flattery nature may fall especially, if a temperature control means is established and it heats and cools. Especially the thickness of a ceramic substrate has 5 optimalmm or less. In addition, the thickness of a ceramic substrate has 1 desirablemm or more.
[0022] Especially the ceramic ingredient that constitutes the ceramic substrate of this invention is not limited, for example, a nitride ceramic, a carbide ceramic, an oxide ceramic, etc. are mentioned.
[0023] As the above-mentioned nitride ceramic, a metal nitride ceramic, for example, alumimium nitride, silicon nitride, boron nitride, etc. are mentioned. Moreover, as the above-mentioned carbide ceramic, a metallic carbide ceramic, for example, silicon carbide, zirconium carbide, tantalum carbide, tungsten carbide, etc. are mentioned.
[0024] As the above-mentioned oxide ceramic, a metallic-oxide ceramic, for example, an alumina, a zirconia, cordierite, a mullite, etc. are mentioned. These ceramics may be used independently and may use two or more sorts together.
[0025] In these ceramics, a nitride ceramic and an oxide ceramic are desirable. Moreover, in a nitride ceramic, alumimium nitride is the most suitable. It is because thermal conductivity is as the highest as 180 W/m-K.
[0026] As for the above-mentioned ceramic substrate, it is desirable to contain 0.1 - 5% of the weight of oxygen. It is because this pore turns into independent pore and withstand voltage improves, also when sintering becomes easy to advance and the nitride ceramic contains pore in this case. At less than 0.1 % of the weight, it is because withstand voltage will fall too by the fall of the elevated-temperature withstand voltage property of an oxide if withstand voltage cannot be secured but it exceeds 5 % of the weight conversely. Moreover, it is because thermal conductivity will fall and a temperature up temperature fall property will fall, if the amount of oxygen exceeds 5 % of the weight.
[0027] For example, in order to make the above-mentioned nitride ceramic contain oxygen, a nitride ceramic is calcinated by the oxidizing atmosphere, or it usually calcinates by mixing a metallic oxide in

the raw material powder of a nitride ceramic. In the case of an oxide ceramic, other oxides are mixed, and it considers as a multiple oxide. As the above-mentioned metallic oxide, yttria (Y2 O3), an alumina (aluminum 2O3), an oxidization rubidium (Rb2 O), lithium oxide (Li2 O), a calcium carbonate (CaCO3), etc. are mentioned, for example. The content of these metallic oxides has 0.1 - 20 desirable % of the weight.

[0028] It is desirable to contain 5-5000 ppm carbon in a ceramic substrate in this invention. By making carbon contain, it is because radiant heat can fully be used in case a ceramic substrate can be black-ized and it is used as a heater. Carbon may be amorphous or may be the thing of a crystalline substance. When decline in a hot volume resistivity can be prevented when amorphous carbon is used, and the thing of a crystalline substance is used, it is because decline in hot thermal conductivity can be prevented. Therefore, depending on an application, both the carbon of a crystalline substance and amorphous carbon may be used together. Moreover, the content of carbon has more desirable 50-2000 ppm.

[0029] The lightness is JIS when making a ceramic substrate contain carbon. Z It is desirable to make carbon contain so that it may be set to four or less N with the value based on a convention of 8721. It is because what has lightness of this level is excellent in the amount of radiant heat, and concealment nature.

[0030] Here, N of lightness sets lightness of ideal black to 0, sets lightness of ideal white to 10, it divides each color into ten so that it may become rates [consciousness / of the brightness of the color] between the lightness of such black, and white lightness, and it expresses it as the notation of N0-N10. Measurement of actual lightness is performed as compared with the color chart corresponding to N0-N10. The 1st place of decimal point in this case is set to 0 or 5.

[0031]

[Embodiment of the Invention] The ceramic substrate of this invention is a ceramic substrate used for the equipment for conducting manufacture of a semi-conductor, and inspection of a semi-conductor, and an electrostatic chuck, a hot plate (ceramic heater), a wafer prober, etc. are mentioned as concrete equipment, for example.

[0032] When the conductor formed in the interior of the above-mentioned ceramic substrate is a resistance heating element, it can be used as a ceramic heater (hot plate). Drawing 1 is the top view showing typically an example of the ceramic heater which is 1 operation gestalt of the ceramic substrate of this invention, and drawing 2 is the partial expanded sectional view showing a part of ceramic heater shown in drawing 1 .

[0033] The ceramic substrate 11 is formed in the shape of a disk type, and the resistance heating element 12 as a temperature control means is formed in the interior of a ceramic substrate 11 at the concentric circular pattern. Moreover, as for these resistance heating element 12, the external terminal 13 of each other which is connected so that the concentric circles of a near duplex may become one line as 1 set of circuits, and turns into a terminal of I/O to the both ends of the circuit is connected through the through hole 19. Moreover, as shown in drawing 2 , the cross section of the both ends of the resistance heating element 12 has become cusp-like, and without for this reason, being hard to generate the crack by a thermal shock etc. in a ceramic substrate 11, and an accumulation phenomenon occurring at the edge of the resistance heating element 12, temperature distribution do not occur in a wafer processing side, but it becomes uniform temperature.

[0034] Moreover, as shown in drawing 2 , a through tube 15 is formed in a ceramic substrate 11, the support pin 26 is inserted in this through tube 15, and the silicon wafer 9 is held. And by going up and down this support pin 26, a silicon wafer 9 is receivable from a conveyance machine, or a silicon wafer 9 can be laid on wafer processing side 11a of a ceramic substrate 11, and can be heated, or a silicon wafer 9 can be supported and heated in the condition of having made it estranging at fixed spacing, from wafer processing side 11a. Moreover, the closed-end hole 14 for inserting temperature measurement components, such as a thermocouple, is formed in base 11a of a ceramic substrate 11. And if it energizes to the resistance heating element 12, a ceramic substrate 11 is heated and, thereby, can perform uniform heating of heated objects, such as a silicon wafer.

[0035] In the case of a ceramic heater, when the cross section of an edge prepares a cusp-like resistance heating element in the interior of a ceramic substrate, it has the effectiveness of this invention which this resistance heating element mentioned above. Moreover, in the case of the electrostatic chuck mentioned later or a wafer prober, a resistance heating element may be prepared in the base of a ceramic substrate. In this case, it has the effectiveness of this invention which these electrodes mentioned above by making the cross section of edges, such as an electrostatic electrode, guard electrodes, and a grand electrode, into the shape of cusp.
[0036] When preparing a resistance heating element in the interior of a ceramic substrate, spray opening of refrigerants, such as Ayr, etc. may be prepared in the support container in which a ceramic substrate is inserted as a cooling means. When preparing a resistance heating element in the interior of a ceramic substrate, two or more layers may be prepared. In this case, the pattern of each class has the desirable condition that were formed so that it might complement mutually, and the pattern was formed in some layer seen from the heating surface. For example, it is the structure which is alternate arrangement mutually.
[0037] As for a resistance heating element, it is desirable that it is what consists of conductive ceramics, such as carbide of metals, such as noble metals (gold, silver, platinum, palladium), lead, a tungsten, molybdenum, and nickel, or a tungsten, and molybdenum. It is because it becomes possible to make resistance high, it is hard to oxidize while being able to thicken the thickness itself in order to prevent an open circuit etc., and thermal conductivity cannot fall easily. These may be used independently and may use two or more sorts together.
[0038] Moreover, since a resistance heating element needs to make temperature of the whole ceramic substrate homogeneity, what combined the pattern of a concentric circle configuration and the pattern of a concentric circle configuration as shown in drawing 1 , and the pattern of a coil-gland configuration is desirable. Moreover, the thickness of a resistance heating element has desirable 1-50 micrometers, and the width of face has 5-20 desirablemm. Moreover, as for this resistance heating element, it is desirable to have the cusp-like section with a width of face of 0.1-200 micrometers.
[0039] Although the resistance can be changed by changing the thickness and width of face of a resistance heating element, it is because the above-mentioned range is the most practical. The resistance of a resistance heating element becomes so large that it becomes thin thinly.
[0040] In addition, if a resistance heating element is prepared in the interior, in order for the distance of a heating surface and a resistance heating element to become near and for the homogeneity of surface temperature to fall, it is necessary to expand the width of face of the resistance heating element itself. Moreover, in order to prepare a resistance heating element in the interior of a ceramic substrate, the need of taking adhesion with a ceramic substrate into consideration is lost.
[0041] Although any of a rectangle, an ellipse form, a spindle shape, and a boiled-fish-paste configuration are sufficient as a cross section, as for a resistance heating element, it is desirable that it is flat, and it is desirable for the cross section of an edge to be the cusp-like. It is because the flatter one tends to radiate heat toward a heating surface, so the amount of heat propagation to a heating surface can be made [many] and the temperature distribution of a heating surface cannot be made easily. In addition, a screw type-like is sufficient as a resistance heating element. In case a resistance heating element is formed in the interior of a ceramic substrate, it is desirable to form in the thickness direction from a base to the field to 60%. It is because the temperature distribution of a heating surface can be abolished and a semi-conductor wafer can be heated to homogeneity. In addition, heated objects, such as a semi-conductor wafer, can be laid in a direct heating surface, and can also be heated. Moreover, from a heating surface, about 50-200 micrometers of heated objects can be made to be able to estrange, they can be held, and can also be heated.
[0042] In order to form a resistance heating element in the base or the interior of the ceramic substrate for semiconductor devices of this invention, it is desirable to use the conductive paste which consists of a metal or a conductive ceramic. That is, in forming a resistance heating element in the base of a ceramic substrate, after calcinating and usually manufacturing a ceramic substrate, a resistance heating element is formed in the front face from forming and calcinating the above-mentioned conductive paste layer. On

the other hand, as shown in drawing 1 and 2, in forming the resistance heating element 12 in the interior of a ceramic substrate 11, after forming the above-mentioned conductive paste layer on a green sheet, pressurize heating with another green sheet, and it is made to unify, and produces the layered product of a green sheet. An edge can form a cusp-like conductive paste layer by heating to the temperature which is extent which to some extent becomes easy to transform the conductive paste after desiccation at this time. Then, the cross section of an edge can produce a cusp-like resistance heating element inside a ceramic substrate by calcinating a layered product.
[0043] Although not limited especially as the above-mentioned conductive paste, in order to secure conductivity, metal particles or a conductive ceramic particle contains, and also the thing containing resin, a solvent, a thickener, etc. is desirable.
[0044] What was mentioned above is mentioned as an ingredient of the above-mentioned metal particles or a conductive ceramic particle. The particle size of these metal particles or a conductive ceramic particle has desirable 0.1-100 micrometers. If too detailed, it will be easy to oxidize with less than 0.1 micrometers, and on the other hand, when it exceeds 100 micrometers, it is because it is hard coming to sinter and resistance becomes large.
[0045] The configuration of the above-mentioned metal particles may be spherical, or may be a piece-like of Lynn. When using these metal particles, you may be the mixture of the above-mentioned spherical object and the above-mentioned Lynn flake.
[0046] When the above-mentioned metal particles are the mixture of the Lynn flake, or the spherical object and the Lynn flake, since it becomes easy to hold the metallic oxide between metal particles, and adhesion of a resistance heating element and a ceramic substrate can be ensured and resistance can be enlarged, it is advantageous.
[0047] As resin used for the above-mentioned conductive paste, acrylic resin, an epoxy resin, phenol resin, etc. are mentioned, for example. Moreover, as a solvent, isopropyl alcohol etc. is mentioned, for example. A cellulose etc. is mentioned as a thickener.
[0048] In case the conductive paste for resistance heating elements is formed on the surface of a ceramic substrate, it is desirable to have added the metallic oxide other than the above-mentioned metal particles in the above-mentioned conductive paste, and to have made the above-mentioned metal particles and the above-mentioned metallic oxide sinter. Thus, a ceramic substrate and metal particles can be stuck more by making a metallic oxide sinter with metal particles.
[0049] Although the reason adhesion with a ceramic substrate is improved by mixing the above-mentioned metallic oxide is not clear, that front face oxidizes slightly, the oxide film is formed, these oxide films sinter and unify the front face of the ceramic substrate which consists of a metal-particles front face or a non-oxide through a metallic oxide, and it is thought that metal particles and a ceramic will stick. Moreover, since a front face naturally consists of an oxide when the ceramic which constitutes a ceramic substrate is an oxide, the conductor layer excellent in adhesion is formed.
[0050] At least one sort chosen from the group which consists of lead oxide, a zinc oxide, a silica, boron oxide (B-2 O3), an alumina, yttria, and a titania as the above-mentioned metallic oxide, for example is desirable. These oxides are because the adhesion of metal particles and a ceramic substrate is improvable, without enlarging the resistance of a resistance heating element.
[0051] The rate of the above-mentioned lead oxide, a zinc oxide, a silica, boron oxide (B-2 O3), an alumina, yttria, and a titania For 20-70, and an alumina, 1-10, and yttria are [1-10, and a silica / 1-30, and boron oxide / 5-50, and a zinc oxide / 1-50, and a titania] 1-50. the case where the whole quantity of a metallic oxide is made into the 100 weight sections -- a weight ratio -- lead oxide -- It is desirable to be adjusted in the range in which the sum total does not exceed the 100 weight sections. In these range, especially adhesion with a ceramic substrate is improvable by adjusting the amount of these oxides.
[0052] The addition to the metal particles of the above-mentioned metallic oxide has less than 10 desirable % of the weight 0.1 % of the weight or more. Moreover, the sheet resistivity at the time of forming a resistance heating element using the conductive paste of such a configuration has desirable 1 - 45mohm/**.
[0053] It is because it will be hard to control the calorific value by the ceramic substrate for

semiconductor devices which calorific value became large too much to the amount of applied voltage, and prepared the resistance heating element in the front face if sheet resistivity exceeds 45mohm/**. In addition, sheet resistivity exceeds 50mohm/** as the addition of a metallic oxide is 10 % of the weight or more, calorific value becomes large too much, temperature control becomes difficult, and the homogeneity of temperature distribution falls.

[0054] When a resistance heating element is formed on the surface of a ceramic substrate, it is desirable that the metallic-coating layer is formed in the surface part of a resistance heating element. It is for preventing that an internal metal sintered compact oxidizes and resistance changes. The thickness of the metallic-coating layer to form has desirable 0.1-10 micrometers.

[0055] Although it will not be limited especially if the metal used in case the above-mentioned metallic-coating layer is formed is a metal of a non-oxidizing quality, specifically, gold, silver, palladium, platinum, nickel, etc. are mentioned. These may be used independently and may use two or more sorts together. In these, nickel is desirable. In addition, covering is unnecessary in order that a resistance heating element front face may not oxidize, in forming a resistance heating element in the interior of a ceramic substrate.

[0056] When the conductor formed in the interior of the above-mentioned ceramic substrate is an electrostatic electrode layer, the above-mentioned ceramic substrate can be used as an electrostatic chuck. In this case, RF electrode and a resistance heating element are the lower parts of an electrostatic electrode, and may be formed as a conductor in the ceramic substrate. Drawing 3 is drawing of longitudinal section having shown typically 1 operation gestalt of the electrostatic chuck concerning this invention, and drawing 4 is an A-A line sectional view in the electrostatic chuck shown in drawing 3 .

[0057] By this electrostatic chuck 101, the electrostatic electrode layer which consists of a chuck positive-electrode electrostatic layer 2 and a chuck negative-electrode electrostatic layer 3 is laid under the interior of the disk type-like ceramic substrate 1, and the thin ceramic layer 4 (henceforth the ceramic dielectric film) is formed on this electrostatic electrode layer. Moreover, the silicon wafer 9 is laid and grounded on the electrostatic chuck 101.

[0058] As shown in drawing 4 , the chuck positive-electrode electrostatic layer 2 It consists of semicircle arc section 2a and ctenidium section 2b, and, similarly the chuck negative-electrode electrostatic layer 3 consists of semicircle arc section 3a and ctenidium section 3b. These chuck positive-electrode electrostatic layers 2 and the chuck negative-electrode electrostatic layer 3 It is arranged face to face so that ctenidium section 2b and 3b may be crossed, and + [of DC power supply] and - side is connected to this chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3, respectively, and it is direct current voltage V2. It is impressed. And as shown in drawing 3 , the cross section of the edge of the resistance heating element 5, and the semicircle arc sections 2a and 3a which constitute the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 and ctenidium section 2b and 3b has become cusp-like.

[0059] Moreover, the resistance heating element 5 of a plane view concentric circle configuration in order to control the temperature of a silicon wafer 9, as shown in drawing 1 is formed in the interior of a ceramic substrate 1, an external terminal is connected and fixed to the both ends of the resistance heating element 5, and it is an electrical potential difference V1. It is impressed. Although not shown in drawing 3 and 4, the through tube for inserting in this ceramic substrate 1 the support pin (not shown) made to go up and down in support of the closed-end hole and silicon wafer 9 for inserting a temperature measurement component, as shown in drawing 1 and 2 is formed. In addition, the resistance heating element may be formed in the base of a ceramic substrate.

[0060] In case this electrostatic chuck 101 is operated, it is direct current voltage V2 to the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3. It impresses. By this, these electrodes will be adsorbed through the ceramic dielectric film 4 according to an electrostatic operation with the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3, and a silicon wafer 9 will be fixed. Thus, after making a silicon wafer 9 fix on the electrostatic chuck 101, various processings of CVD etc. are performed to this silicon wafer 9. By the electrostatic chuck 101 concerning this invention, since the cross section of the edge of the chuck

positive/negative music electrostatic layers 2 and 3 is the cusp-like, electric field concentrate along this edge and the big chuck force is attracted. Moreover, since the cross section of the edge of the chuck positive/negative music electrostatic layers 2 and 3 or the resistance heating element 5 is the cusp-like, it is hard to generate a crack and an accumulation phenomenon does not occur at the edge of the resistance heating element 5.

[0061] It consists of a nitride ceramic to which the ceramic dielectric film 4 contains oxygen by the above-mentioned electrostatic chuck 101, and porosity is 5% or less, and it is desirable for the greatest pore diameter to be 50 micrometers or less. Moreover, as for the pore in this ceramic dielectric film 4, to be constituted by the pore which carried out mutually-independent is desirable. In such ceramic dielectric film 4 of a configuration, the gas in which withstand voltage is reduced penetrates the ceramic dielectric film, an electrostatic electrode is not made to corrode or the withstand voltage of the ceramic dielectric film does not fall at an elevated temperature, either.

[0062] As a temperature control means, the Peltier device (refer to drawing 7) other than the resistance heating element 12 is mentioned. changing the direction where a current flows, when using a Peltier device as a temperature control means -- both generation of heat and cooling -- **** -- since things are made, it is advantageous. As shown in drawing 7 , Peltier device 8 connects the thermoelement 81 of p mold and n mold to a serial, and is formed by joining this to the ceramic plate 82 etc. As a Peltier device, a silicon germanium system, a bismuth antimony system, lead, a tellurium system ingredient, etc. are mentioned, for example.

[0063] The electrostatic chuck of this invention has drawing 3 and a configuration as shown in 4. Although the ingredient of a ceramic substrate was already explained, other operation gestalten of each part material which constitutes the other above-mentioned electrostatic chucks below, and the electrostatic chuck of this invention are explained to the detail one by one.

[0064] Especially the ingredient of the ceramic dielectric film which constitutes the electrostatic chuck of this invention has a desirable nitride ceramic in these, although it is not limited but an oxide ceramic, a nitride ceramic, an oxide ceramic, etc. are mentioned. As the above-mentioned nitride ceramic, the same thing as the above-mentioned ceramic substrate is mentioned. As for the above-mentioned nitride ceramic, it is desirable to contain oxygen. In this case, also when sintering becomes easy to advance and the nitride ceramic contains pore, this pore turns into independent pore and its withstand voltage improves.

[0065] In order to make the above-mentioned nitride ceramic contain oxygen, it usually calcinates by mixing a metallic oxide in the raw material powder of a nitride ceramic. As the above-mentioned metallic oxide, an alumina (aluminum-2O3), oxidation silicon (SiO2), etc. are mentioned. The addition of these metallic oxides has desirable 0.1 - 10 weight section to the nitride ceramic 100 weight section.

[0066] Sufficient withstand voltage can be secured by setting thickness of the ceramic dielectric film to 50-5000 micrometers, without reducing the chuck force. Since thickness is too thin in the thickness of the above-mentioned ceramic dielectric film being less than 50 micrometers, sufficient withstand voltage is not obtained, but a silicon wafer is laid, and if the ceramic dielectric film may carry out dielectric breakdown and the thickness of the above-mentioned ceramic dielectric film exceeds 5000 micrometers on the other hand, when it adsorbs, since the distance of a silicon wafer and an electrostatic electrode will become far, the capacity to adsorb a silicon wafer will become low. The thickness of the ceramic dielectric film has desirable 100-1500 micrometers.

[0067] The pore diameter of the maximum pore has [the porosity of the above-mentioned ceramic dielectric film] desirable 50 micrometers or less 5% or less. If the above-mentioned porosity exceeds 5%, the number of pores will increase, a pore diameter will become large too much, consequently it will become easy to open pores for free passage. Withstand voltage will fall by such ceramic dielectric film of structure. Furthermore, if the pore diameter of the maximum pore exceeds 50 micrometers, even if the oxide exists in the particle boundary, withstand voltage in an elevated temperature is not securable. 0.01 - 3% of porosity is desirable, and the pore diameter of the maximum pore has desirable 0.1-10 micrometers.

[0068] In the above-mentioned ceramic dielectric film, it is desirable for carbon to contain 50-5000

ppm. It is because the electrode pattern prepared into the electrostatic chuck can be concealed and high radiant heat is obtained. Moreover, in a low-temperature region, the adsorption capacity force of a silicon wafer becomes [the one where a volume resistivity is lower] high.
[0069] In addition, it supposes that a certain amount of pore may exist in the ceramic dielectric film by this invention because a fracture toughness value can be made high, and thereby, it can improve thermal shock nature.
[0070] As the above-mentioned electrostatic electrode, a metal or the sintered compact of a conductive ceramic, a metallic foil, etc. are mentioned, for example. What consists of at least one sort chosen from a tungsten and molybdenum as a metal sintered compact is desirable. It is desirable for a metallic foil to also consist of the same quality of the material as a metal sintered compact. It is because these metals cannot oxidize comparatively easily and it has conductivity sufficient as an electrode. In this case, it is made the shape of cusp by heating and pressurizing the edge of a metallic foil or performing chemical and physical etching. As chemical etching, etching by the acid and the alkali water solution is mentioned, and ion beam etching, plasma etching, etc. are mentioned as physical etching. Moreover, as a conductive ceramic, at least one sort chosen from the carbide of a tungsten and molybdenum can be used.
[0071] Drawing 9 and drawing 10 are the horizontal sectional views having shown the electrostatic electrode in other electrostatic chucks typically, by the electrostatic chuck 20 shown in drawing 9 , the chuck positive-electrode electrostatic hemicycle-like layer 22 and the chuck negative-electrode electrostatic layer 23 are formed in the interior of a ceramic substrate 1, and the chuck positive-electrode electrostatic layers 32a and 32b of a configuration and the chuck negative-electrode electrostatic layers 33a and 33b which quadrisected the circle are formed in the interior of a ceramic substrate 1 in the electrostatic chuck shown in drawing 10 . Moreover, the positive-electrode electrostatic layers 22a and 22b of two sheets and the chuck negative-electrode electrostatic layers 33a and 33b of two sheets are formed so that it may cross, respectively.
[0072] The cross section of the edge of these electrostatic electrodes is also the cusp-like, therefore electric field concentrate along the edge of an electrostatic electrode, and the big chuck force is attracted. Moreover, it is hard to generate a crack in a ceramic substrate. In addition, when forming the electrode of a gestalt with which electrodes, such as a round shape, were divided, especially the number of partitions is not limited, you may be 5 or more ****s and the configuration is not limited to a sector, either.
[0073] As an electrostatic chuck in this invention, as shown in drawing 3 , for example As shown in the electrostatic chuck 101 of a configuration of that the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 were formed between a ceramic substrate 1 and the ceramic dielectric film 4, and the resistance heating element 5 was formed in the interior of a ceramic substrate 1, and drawing 5 As shown in the electrostatic chuck 201 of a configuration of that the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 were formed between a ceramic substrate 1 and the ceramic dielectric film 4, and the resistance heating element 25 was formed in the base of a ceramic substrate 1, and drawing 6 The chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 are formed between a ceramic substrate 1 and the ceramic dielectric film 4. As shown in the electrostatic chuck 301 of a configuration of that the metal wire 7 which is a resistance heating element was laid under the interior of a ceramic substrate 1, and drawing 7 The chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 are formed between a ceramic substrate 1 and the ceramic dielectric film 4, and the electrostatic chuck 401 grade of a configuration of that Peltier device 8 which consists of a thermoelement 81 and a ceramic plate 82 was formed in the base of a ceramic substrate 1 is mentioned. In these electrostatic chucks, each cross section of the edge of an electrostatic electrode layer is the cusp-like, for this reason, the big chuck force is attracted and a crack cannot generate it easily in a ceramic substrate.
[0074] In this invention, since the chuck positive-electrode electrostatic layer 2 and the chuck negative-electrode electrostatic layer 3 are formed between a ceramic substrate 1 and the ceramic dielectric film 4

and the resistance heating element 5 and the metal wire 7 are formed in the interior of a ceramic substrate 1 as shown in drawing 3 -7, the connections (through hole) 16 and 17 for connecting these and an external terminal are needed. Through holes 16 and 17 are formed by being filled up with conductive ceramics, such as refractory metals, such as a tungsten paste and a molybdenum paste, tungsten carbide, and molybdenum carbide.
[0075] Moreover, the diameter of connections (through hole) 16 and 17 has 0.1-10 desirablemm. It is because a crack and distortion can be prevented, preventing an open circuit. The external terminals 6 and 18 are connected by using this through hole as a connection pad (refer to drawing 8 (d)).
[0076] Connection is made by solder and wax material. As wax material, silver solder, a palladium wax, an aluminum wax, and a golden wax are used. As a golden wax, an Au-nickel alloy is desirable. An Au-nickel alloy is because it excels in adhesion with a tungsten.
[0077] The ratio of Au/nickel has desirable [81.5-82.5(% of the weight)]/[18.5-17.5 (% of the weight)]. The thickness of an Au-nickel layer has desirable 0.1-50 micrometers. It is because it is sufficient range to secure connection. Moreover, although it will deteriorate with an Au-Cu alloy if it is used at a 500-1000-degree C elevated temperature by the high vacuum of 10-6 to ten to 5 Pa, it is [such no degradation] and is advantageous with an Au-nickel alloy. Moreover, when the whole quantity is made into the 100 weight sections, as for the amount of impurity elements in an Au-nickel alloy, it is desirable that it is under 1 weight section.
[0078] In this invention, a thermocouple can be embedded at the closed-end hole of a ceramic substrate if needed. It is because the temperature of a resistance heating element can be measured with a thermocouple, an electrical potential difference and the amount of currents can be changed based on the data and temperature can be controlled. The magnitude like the joint of the metal wire of a thermocouple is the same as that of the diameter of a strand of each metal wire, or is larger than it, and its 0.5mm or less is good. By such configuration, the heat capacity for a joint becomes small and temperature is changed into a current value correctly and quickly. For this reason, temperature control nature improves and the temperature distribution of the heating surface of a wafer become small. As the above-mentioned thermocouple, K mold, an R form, B mold, a smooth S form, E mold, J mold, and a copper constantan thermocouple are mentioned, for example so that it may be mentioned to JIS-C -1602 (1980).

[0079] Drawing 11 is the sectional view having shown typically the support container 41 for inserting in the electrostatic chuck of this invention of the above configurations. The electrostatic chuck 101 is inserted in the support container 41 through a heat insulator 45. Moreover, the refrigerant diffuser 42 is formed in this support container 11, a refrigerant can be blown into it from the refrigerant inlet 44, it can go away outside from the suction opening 43 through the refrigerant diffuser 42, and the electrostatic chuck 101 can be cooled now according to an operation of this refrigerant.
[0080] Next, an example of the manufacture approach of the electrostatic chuck which is an example about the ceramic substrate of this invention is explained based on the sectional view shown in drawing 8 (a) - (d).
(1) First, mix the fine particles of ceramics, such as a nitride ceramic and a carbide ceramic, with a binder and a solvent, and obtain a green sheet 50. As ceramic powder mentioned above, the alumimium nitride powder containing oxygen etc. can be used, for example. Moreover, sintering acid, such as an alumina and sulfur, may be added if needed.
[0081] In addition, since green sheet of several sheet or one sheet 50' which carries out a laminating on the green sheet with which the electrostatic electrode layer printing hand 51 mentioned later was formed is a layer used as the ceramic dielectric film 4, it is good also as presentation with an another ceramic substrate by the need. However, as for the raw material of the ceramic dielectric film 4, and the raw material of a ceramic substrate 1, it is usually desirable to use the same thing. It is because baking conditions become the same in order to sinter these as one in many cases. However, when ingredients differ, the ceramic substrate is manufactured first, an electrostatic electrode layer can be formed on it, and the ceramic dielectric film can also be further formed on it.
[0082] Moreover, as a binder, at least one sort chosen from an acrylic binder, ethyl cellulose, butyl

cellosolve, and polyvinyl alcohol is desirable. Furthermore, as a solvent, at least one sort chosen from alpha-terpineol and a glycol is desirable. The paste which mixes these and is obtained is fabricated with a doctor blade method in the shape of a sheet, and a green sheet 50 is produced.
[0083] A through tube can be prepared in the through tube which inserts the support pin of a silicon wafer in a green sheet 50 if needed, the crevice embedding a thermocouple, the part which forms a through hole. A through tube can be formed by punching etc. The thickness of a green sheet 50 has about 0.1-5 desirablemm.
[0084] Next, the conductive paste which fills up the through tube of a green sheet 50 with conductive paste, and obtains the through hole printing hands 53 and 54, next serves as an electrostatic electrode layer and a resistance heating element on a green sheet 50 is printed. Printing is performed so that a desired aspect ratio may be obtained in consideration of contraction of a green sheet 50, and this obtains the electrostatic electrode layer printing hand 51 and the resistance heating element layer printing hand 52. A printing hand is formed by printing the conductive paste containing a conductive ceramic, metal particles, etc.
[0085] As a conductive ceramic particle contained during these conductive pastes, the carbide of a tungsten or molybdenum is the optimal. It is because it is hard to oxidize and thermal conductivity cannot fall easily. Moreover, as metal particles, a tungsten, molybdenum, platinum, nickel, etc. can be used, for example.
[0086] The mean particle diameter of a conductive ceramic particle and metal particles has desirable 0.1-5 micrometers. even if these particles are too large and it is too small -- a conductor -- it is because it is hard to print the ** paste. the conductor which carried out 1.5-10 weight section mixing, and prepared at least one sort of solvents chosen from at least one sort of binders 1.5 chosen from metal particles or the conductive ceramic particle 85 - 97 weight sections, acrylic, ethyl cellulose, butyl cellosolve, and polyvinyl alcohol - 10 weight sections, alpha-terpineol, a glycol, ethyl alcohol, and a butanol as such a paste -- the ** **-strike is the optimal.
[0087] Next, as shown in drawing 8 (a), the laminating of the green sheet 50 which has printing hands 51, 52, 53, and 54, and green sheet 50' which does not have a printing hand is carried out. The laminating of green sheet 50' which does not have a printing hand is carried out to a resistance heating element formation side for preventing the end face of a through hole being exposed and oxidizing in the case of baking of resistance heating element formation. As long as it calcinates resistance heating element formation, with the end face of a through hole exposed, it is necessary to carry out sputtering of the metals which cannot oxidize easily, such as nickel, and you may cover with the golden wax of Au-nickel still more preferably.
[0088] (2) Next, as shown in drawing 8 (b), perform heating and pressurization of a layered product and form the layered product of a green sheet. Since a conductive paste layer is pressurized at this time, if the conductive paste layer containing a suitable binder is formed, the cross section of an edge will become cusp-like. The pressure at the time of whenever [stoving temperature / of a layered product] having desirable 50-300 degrees C, and being pressurization is 20-200kg/cm2. It is desirable. Then, a green sheet and conductive paste are made to sinter. For the temperature in the case of baking, the pressure of the pressurization in the case of 1000-2000 degrees C and baking is 100-200kg/cm2. It is desirable. These heating and pressurization are performed under an inert gas ambient atmosphere. An argon, nitrogen, etc. can be used as inert gas. At this baking process, the chuck positive-electrode electrostatic cusp-like layer 2, the chuck negative-electrode electrostatic layer 3, and resistance heating element 5 grade are formed for the end face of through holes 16 and 17 and an edge.
[0089] (3) Next, as shown in drawing 8 (c), form the sac holes 35 and 36 for external terminal strapping. the wall of sac holes 35 and 36 -- the -- at least -- the part -- **** -- are-izing and, as for the electric-conduction-ized wall, it is desirable to connect with the chuck positive-electrode electrostatic layer 2, the chuck negative-electrode electrostatic layer 3, and resistance heating element 5 grade.
[0090] (7) Finally, as shown in drawing 8 (d), form the external terminals 6 and 18 in sac holes 35 and 36 through a golden wax. Furthermore, if needed, a closed-end hole can be prepared and a thermocouple can be embedded to the interior. Solder can use alloys, such as silver-lead and lead-tin and bismuth-tin.

In addition, the thickness of a solder layer has desirable 0.1-50 micrometers. It is because it is sufficient range to secure connection by solder.

[0091] In addition, what is necessary is to print and calcinate conductive paste on the base of this ceramic plate, to form the resistance heating element 25 in it, and just to form metallic-coating layer 25a in it with nonelectrolytic plating etc. after this, after manufacturing the ceramic plate which has an electrostatic electrode layer, when manufacturing the electrostatic chuck 201 (refer to drawing 5) although the electrostatic chuck 101 (refer to drawing 3) was made into the example in the above-mentioned explanation. Moreover, what is necessary is to use a metallic foil and a metal wire as an electrostatic electrode or a resistance heating element, to embed them into ceramic powder, and just to sinter, when manufacturing the electrostatic chuck 301 (refer to drawing 6). Furthermore, what is necessary is just to join a Peltier device to this ceramic plate through a thermal-spraying metal layer, after manufacturing the ceramic plate which has an electrostatic electrode layer, when manufacturing the electrostatic chuck 401 (refer to drawing 7).

[0092] A conductor is arranged in the front face and the interior of a ceramic substrate of this invention, a surface conductor layer is a chuck top conductor layer, even if guard electrodes or a grand electrode has few internal conductors either, on the other hand, it comes out, and, in a certain case, the above-mentioned ceramic substrate functions as a wafer prober.

[0093] Drawing 12 is the sectional view having shown typically 1 operation gestalt of the wafer prober of this invention, and drawing 13 is an A-A line sectional view in the wafer prober shown in drawing 12 . In this wafer prober 501, while the slot 67 of a plane view concentric circle configuration is formed in the front face of the disk type-like ceramic substrate 63, two or more suction holes 68 for attracting a silicon wafer are formed in a part of slot 67, and the chuck top conductor layer 62 for connecting with most ceramic substrates 63 including a slot 67 with the electrode of a silicon wafer is formed in the circle configuration.

[0094] On the other hand, in order to control the temperature of a silicon wafer, the resistance heating element 61 of a plane view concentric circle configuration as shown in drawing 1 is formed, and the external terminal (not shown) is being connected and fixed to the both ends of the resistance heating element 61 by the base of a ceramic substrate 63. Moreover, in order to remove a stray capacitor and a noise, the guard electrodes 65 and the grand electrode 66 (refer to drawing 13) of a plane view grid configuration are prepared in the interior of a ceramic substrate 63. The cross section of the edge of guard electrodes 65 and the grand electrode 66 has become cusp-like, and, for this reason, it is hard to generate a crack in a ceramic substrate. In the above-mentioned electrostatic chuck, in this case, if the cross section of the edge of the resistance heating element 61 is made into the shape of cusp, it will be hard to generate a crack in a ceramic substrate, and will be hard to form the resistance heating element 61 in the interior of a ceramic substrate 63, and to generate an accumulation phenomenon at the edge of the resistance heating element 61. In addition, the quality of the material of guard electrodes 65 and the grand electrode 66 is easy to be the same as that of an electrostatic electrode.

[0095] The thickness of the above-mentioned chuck top conductor layer 62 has desirable 1-20 micrometers. It is because it will become easy to exfoliate with the stress which a conductor has in less than 1 micrometer if resistance becomes high too much, and does not work as an electrode but exceeds 20 micrometers on the other hand.

[0096] As a chuck top conductor layer 62, at least one sort of metals chosen from refractory metals, such as copper, titanium, chromium, nickel, noble metals (gold, silver, platinum, etc.), a tungsten, and molybdenum, can be used, for example.

[0097] In such a wafer prober of a configuration, after laying the silicon wafer with which the integrated circuit was formed on it, pushing the probe card which has a circuit tester pin in this silicon wafer, and heating and cooling, an electrical potential difference can be impressed and a continuity test can be performed. In addition, what is necessary is to perform sputtering, plating, etc. to the surface part in which the ceramic substrate under which the resistance heating element was laid first was manufactured like the case of for example, an electrostatic chuck, and the slot was formed in the front face of a ceramic substrate after that, then the slot was formed, and just to form a metal layer, in manufacturing a

wafer prober.
[0098]
[Example] Hereafter, this invention is further explained to a detail.
(Example 1) Using the paste which mixed 53 alcoholic weight sections which consist of the manufacture (1) alumimium-nitride powder (Tokuyama make, mean particle diameter of 1.1 micrometers) 100 weight section, the yttria (mean particle diameter: 0.4 micrometers) 4 weight section, the acrylic binder 11.5 weight section, the dispersant 0.5 weight section and 1-butanol, and ethanol of an electrostatic chuck (refer to drawing 3), shaping by the doctor blade method was performed and the green sheet with a thickness of 0.47mm was obtained.
[0099] (2) Next, after drying this green sheet at 80 degrees C for 5 hours, the part used as the through hole for connecting with the part and external terminal used as the through tube which inserts a semi-conductor wafer support pin (the diameter of 1.8mm, 3.0mm, and 5.0mm) by punching was prepared.
[0100] (3) The tungsten carbide particle 100 weight section with a mean particle diameter of 1 micrometer, the acrylic binder 3.0 weight section, the alpha-terpineol solvent 3.5 weight section, and the dispersant 0.3 weight section were mixed, and conductive paste A was prepared. The tungsten particle 100 weight section with a mean particle diameter of 3 micrometers, the acrylic binder 1.9 weight section, the alpha-terpineol solvent 3.7 weight section, and the dispersant 0.2 weight section were mixed, and conductive paste B was prepared. This conductive paste A was printed by screen-stencil to the green sheet, and the conductive paste layer was formed. The printing pattern was used as the concentric circle pattern. Moreover, the conductive paste layer which consists of an electrostatic electrode pattern of the configuration shown in other green sheets at drawing 4 was formed.
[0101] Furthermore, the through tube for the through holes for connecting an external terminal was filled up with conductive paste B. Further green sheet 50' which does not print a tungsten paste to the green sheet 50 which the above-mentioned processing finished to the up side (heating surface) 34 sheets, Turn a 13-sheet laminating down and the laminating of the green sheet 50 which printed the conductive paste layer which consists of an electrostatic electrode pattern on it is carried out. The two-sheet laminating of green sheet 50' which furthermore is not printing the tungsten paste on it is carried out, and they are these 130 degrees C and 80kg/cm2 It was stuck by pressure by the pressure and the layered product was formed (drawing 8 (a)).
[0102] (4) Next, degrease the obtained layered product at 600 degrees C among nitrogen gas for 5 hours, and they are 1890 degrees C and the pressure of 150kg/cm2. The hotpress was carried out for 3 hours and the alumimium nitride plate with a thickness of 3mm was obtained. This was started to disc-like [230mm], and it considered as the plate made from alumimium nitride which has the resistance heating element 5 with 6 micrometers [in thickness], and a width of face of 10mm and the chuck positive-electrode electrostatic layer 2 with a thickness of 10 micrometers, and the chuck negative-electrode electrostatic layer 3 inside (drawing 8 (b)).
[0103] (5) Next, after grinding the plate obtained by (4) by the diamond wheel, the mask was laid and the closed-end hole for a thermocouple (diameter: 1.2mm, depth:2.0mm) was prepared in the front face by the blasting processing by SiC etc.
[0104] (6) The part in which the through hole is formed was scooped out further, it considered as sac holes 35 and 36 (drawing 8 (c)), a heating reflow was carried out at 700 degrees C using the golden wax which becomes these sac holes 35 and 36 from nickel-Au, and the external terminals 6 and 18 made from covar were connected (drawing 8 (d)). In addition, connection of an external terminal has the desirable structure which the base material of a tungsten supports by three points. It is because connection dependability is securable.
[0105] (7) Next, two or more thermocouples for temperature control were embedded at the closed-end hole, and manufacture of the electrostatic chuck which has a resistance heating element was completed. The ceramic substrate which constitutes the obtained electrostatic chuck was made to fracture so that an electrostatic electrode layer may be contained, and the cross section was observed with the scanning electron microscope (SEM). The result is shown in drawing 14 . By drawing 14 , the cross section of the edge of an electrostatic electrode layer has become cusp-like so that clearly.

[0106] (Example 1 of a comparison) Although it was the same as that of an example 1, the laminating of the green sheet was carried out, without heating at 25 degrees C. When observed by electron microscope observation (500 times), it had the field where a cross-section edge is perpendicular to a wafer processing side also to an electrostatic electrode and a resistance heating element.
[0107] (Example 2) The mixed constituent which mixed and obtained the 530 alcoholic weight sections which consist of the manufacture (1) alumimium-nitride powder (Tokuyama make, mean particle diameter of 1.1 micrometers) 1000 weight section, the yttria (mean particle diameter of 0.4 micrometers) 40 weight section, 1-butanol, and ethanol of the wafer prober 201 (refer to drawing 12) was fabricated using the doctor blade method, and the green sheet with a thickness of 0.47mm was obtained.
[0108] (2) Next, after drying this green sheet at 80 degrees C for 5 hours, the through tube for the through holes for connecting with a resistance heating element and an external terminal pin in punching was prepared.
[0109] (3) The tungsten-carbide particle 100 weight section with a mean particle diameter of 1 micrometer, the acrylic binder 3.0 weight section, alpha-terpineol solvent 3.5 weight, and the dispersant 0.3 weight section were mixed, and it considered as the conductive paste A. Moreover, the 3.7 weight sections and the dispersant 0.2 weight section were mixed, and the tungsten particle 100 weight section with a mean particle diameter of 3 micrometers, the acrylic binder 1.9 weight section, and alpha-terpineol solvent were considered as the conductive paste B.
[0110] Next, the grid-like printing hand for guard electrodes, and the printing hand for grand electrodes were printed by the screen-stencil which used this conductive paste A for the green sheet. Moreover, the through tube for the through holes for connecting with a terminal pin was filled up with the conductive paste B.
[0111] Furthermore, the 50-sheet laminating of the green sheet with which the green sheet and printing which were printed are not carried out is carried out, and they are 130 degrees C and 80kg/cm2. The layered product was produced by unifying by the pressure.
[0112] (4) Next, degrease this layered product at 600 degrees C in nitrogen gas for 5 hours, and they are 1890 degrees C and the pressure of 150kg/cm2. The hotpress was carried out for 3 hours and the alumimium nitride plate with a thickness of 3mm was obtained. The obtained plate was cut down in the circle configuration with a diameter of 300mm, and was used as the plate made from a ceramic. The magnitude of a through hole 17 was 0.2mm in the diameter of 0.2mm, and depth.
[0113] Moreover, the thickness of guard electrodes 65 and the grand electrode 66 was [the formation location of 1mm and the grand electrode 66 of 10 micrometers and the formation location of guard electrodes 65] 1.2mm from the wafer installation side from the wafer installation side. moreover, the conductor of guard electrodes 65 and the grand electrode 66 -- the magnitude of one side of agenesis field 66a was 0.5mm.
[0114] (5) After grinding the plate obtained above (4) with a diamond grinding stone, the mask was laid and the crevice for a thermocouple and the slot 67 (width of face of 0.5mm, a depth of 0.5mm) for wafer adsorption were established in the front face by the blasting processing by SiC etc.
[0115] (6) The layer for forming the resistance heating element 61 in the field which counters a wafer installation side further was printed. Printing used conductive paste. Tokuriki Chemical Research Sol Best PS603D currently used for through hole formation of a printed wired board was used for conductive paste. This conductive paste was silver / lead paste, and was a 7.5 weight ****** thing to the silver 100 weight section about the metallic oxide (each weight ratio is 5/55/10/25/5) which consists of lead oxide, a zinc oxide, a silica, boron oxide, and an alumina. Moreover, the silver configuration was a piece of Lynn-like thing in the mean particle diameter of 4.5 micrometers.
[0116] (7) Heating baking of the ceramic substrate 63 which printed conductive paste was carried out at 780 degrees C, and while making the silver in conductive paste, and lead sinter, it was able to be burned on the ceramic substrate 63. the non-electrolyzed nickel-plating bath which consists of a water solution which furthermore contains nickel-sulfate 30 g/l, way acid 30 g/l, ammonium-chloride 30 g/l, and a 60g [/l.] Rochell salt -- a heater plate -- being immersed -- a silver sintered compact -- empty -- 1 micrometer in thickness and the content of boron deposited 1 or less % of the weight of the nickel layer

(not shown) on the front face of the resistance heating element 61. Then, the heater plate performed annealing processing at 120 degrees C for 3 hours. Thickness was 2.4mm in 5 micrometers and width of face, and the sheet resistivity of the resistance heating element which consists of a silver sintered compact was 7.7mohm/**.
[0117] (8) The titanium layer, the molybdenum layer, and the nickel layer were formed in the field in which the slot 67 was formed one by one by the sputtering method. SV-4540 by Japan vacuum-technology incorporated company were used for the equipment for sputtering. The conditions of sputtering are the atmospheric pressure of 0.6Pa, the temperature of 100 degrees C, and power 200W, and each metal adjusted sputtering time amount within the limits of 1 minute from 30 seconds. For the thickness of the obtained film, the image of an X-ray fluorescence meter to the titanium layer was [2 micrometers and the nickel layer of 0.3 micrometers and a molybdenum layer] 1 micrometer.
[0118] (9) The ceramic substrate 63 obtained above (8) was immersed in the non-electrolyzed nickel-plating bath which consists of a water solution containing nickel-sulfate 30 g/l, way acid 30 g/l, ammonium-chloride 30 g/l, and Rochell salt 60 g/l, and 7 micrometers in thickness and the content of boron deposited 1 or less % of the weight of the nickel layer on the front face of the metal layer formed of sputtering, and carried out annealing to it at 120 degrees C for 3 hours. A resistance heating element front face does not pass a current, and is not covered with electrolysis nickel plating.
[0119] Furthermore, it was immersed for 1 minute on 93-degree C conditions, and the gilding layer with a thickness of 1 micrometer was formed on the nickel-plating layer at the non-electrolyzed gilding liquid which contains gold cyanide potassium 2 g/l, ammonium-chloride 75 g/l, sodium-citrate 50 g/l, and sodium hypophosphite 10 g/l on a front face.
[0120] (10) The air suction hole 68 which falls out from a slot 67 at the rear face was formed by drilling, and the sac hole (not shown) for exposing a through hole 16 further was prepared. Using the golden wax which consists of a nickel-Au alloy (81.5 % of the weight of Au(s), 18.4 % of the weight of nickel, 0.1 % of the weight of impurities), a heating reflow was carried out to this sac hole at 970 degrees C, and the external terminal pin made from covar was connected to it. Moreover, the external terminal pin made from covar was formed in the resistance heating element through solder (90 % of the weight of tin, 10 % of the weight of lead).
[0121] (11) Next, two or more thermocouples for temperature control were embedded in the crevice, and the wafer prober heater 201 was obtained.
[0122] The pore diameter of the maximum pore was 2 micrometers, and porosity of the ceramic substrate was 1%. Moreover, although the temperature of a ceramic substrate was raised to 200 degrees C, dielectric breakdown was not produced even if impressed 200V. Furthermore, the amount of camber was also good at 1 micrometer or less.
[0123] (Example 2 of a comparison) Although it was the same as that of an example 2, the laminating of the green sheet was carried out, without heating at 25 degrees C. When observed by electron microscope observation (500 times), it had the field where a cross-section edge is perpendicular to a wafer processing side also to guard electrodes and a grand electrode.
[0124] (Example 3) Alumina hot plate (drawing 1 , 2 reference)
(1) Alumina : 93 % of the weight, SiO2 : 5 % of the weight, CaO:0.5 % of the weight, MgO:0.5 % of the weight, TiO2 : 0.5% of the weight, using the paste which mixed alcoholic:53 weight section which consists of the acrylic binder:11.5 weight section, the dispersant:0.5 weight section and 1-butanol, and ethanol, shaping by the doctor blade method was performed and the green sheet with a thickness of 0.47mm was obtained.
(2) Next, after drying these green sheets at 80 degrees C for 5 hours, the part used as the through hole for connecting with the part and external terminal with which processing serves as a through tube which inserts a semi-conductor wafer support pin (the diameter of 1.8mm, 3.0mm, and 5.0mm) by punching to a required green sheet was prepared.
[0125] (3) The tungsten particle 100 weight section with a mean particle diameter of 3 micrometers, the acrylic binder 1.9 weight section, the alpha-terpineol solvent 3.7 weight section, and the dispersant 0.2 weight section were mixed, and conductive paste B was prepared. This conductive paste B was printed

by screen-stencil to the green sheet, and the conductive paste layer was formed. The printing pattern was used as the concentric circle pattern.
[0126] (4) The through tube for the through holes for connecting an external terminal was further filled up with conductive paste B. The 30-sheet laminating of the green sheet which does not print a tungsten paste is further turned to the green sheet with which the pattern of a resistance heating element was formed from 13 sheets up (heating surface) with 34 sheets to 60 sheets, and the down side, and they are these 130 degrees C and 80kg/cm2 It was stuck by pressure by the pressure and the layered product was formed.
[0127] (5) Next, degrease the obtained layered product at 600 degrees C among air for 5 hours, and they are 1600 degrees C and the pressure of 150kg/cm2. The hotpress was carried out for 2 hours and the alumina plate with a thickness of 3mm was obtained. Processing conditions and polish conditions were changed and this was made into the substrate with a thickness of 19mm for the diameter 280. It considered as the plate made from an alumina which has the resistance heating element 5 with 6 micrometers [in thickness], and a width of face of 10mm inside.
[0128] (6) Next, after grinding the plate obtained by (3) by the diamond wheel, the mask was laid and the closed-end hole for a thermocouple (diameter: 1.2mm, depth:2.0mm) was prepared in the front face by the blasting processing by SiC etc.
[0129] (7) The part in which the through hole is formed was scooped out further, it considered as the sac hole, a heating reflow was carried out at 700 degrees C using the golden wax which becomes this sac hole from nickel-Au, and the external terminal made from covar was connected. In addition, connection of an external terminal has the desirable structure which the base material of a tungsten supports by three points. It is because connection dependability is securable.
[0130] (8) Next, two or more thermocouples for temperature control were embedded at the closed-end hole, and the hot plate manufacture which has a resistance heating element was completed.
[0131] (Example 3 of a comparison) Although it was the same as that of an example 3, the laminating of the green sheet was carried out, without heating at 25 degrees C. According to electron microscope observation (500 times), the cross-section edge of a resistance heating element had a field perpendicular to a wafer processing side.
[0132] (Example 4) The hot plate made from alumimium nitride (drawing 1 , 2 reference)
(1) Using the paste which mixed 53 alcoholic weight sections which consist of the alumimium nitride powder (Tokuyama make, mean particle diameter of 1.1 micrometers) 100 weight section, the yttria (mean particle diameter: 0.4 micrometers) 4 weight section, the acrylic binder 11.5 weight section, the dispersant 0.5 weight section, the acrylic resin binder (Kyoeisha trade name KC-600 acid-number 17 KOHmg/g) 8 weight section and 1-butanol, and ethanol, shaping by the doctor blade method was performed and the green sheet with a thickness of 0.47mm was obtained.
[0133] (2) Next, after drying this green sheet at 80 degrees C for 5 hours, the part used as the through hole for connecting with the part and external terminal used as the through tube which inserts a semi-conductor wafer support pin (the diameter of 1.8mm, 3.0mm, and 5.0mm) by punching was prepared.
[0134] (3) The tungsten carbide particle 100 weight section with a mean particle diameter of 1 micrometer, the acrylic binder 3.0 weight section, the alpha-terpineol solvent 3.5 weight section, and the dispersant 0.3 weight section were mixed, and conductive paste A was prepared. The tungsten particle 100 weight section with a mean particle diameter of 3 micrometers, the acrylic binder 1.9 weight section, the alpha-terpineol solvent 3.7 weight section, and the dispersant 0.2 weight section were mixed, and conductive paste B was prepared. This conductive paste A was printed by screen-stencil to the green sheet, and the conductive paste layer was formed. The printing pattern was used as the concentric circle pattern. Moreover, the conductive paste layer which consists of an electrostatic electrode pattern of the configuration shown in other green sheets at drawing 10 was formed.
[0135] Furthermore, the through tube for the through holes for connecting an external terminal was filled up with conductive paste B. It is the green sheet which does not print a tungsten paste further to the green sheet which the above-mentioned processing finished to 37 sheets and the bottom in the bottom (heating surface) 13 sheets, 130 degrees C, and 80kg/cm2 The laminating was carried out by the

pressure.
[0136] (4) Next, degrease the obtained layered product at 600 degrees C among nitrogen gas for 1 hour, and they are 1890 degrees C and the pressure of 150kg/cm2. The hotpress was carried out for 3 hours and the alumimium nitride plate with a thickness [containing 810 ppm of carbon] of 3mm was obtained. This was started to disc-like [230mm], and it considered as the plate made from a ceramic which has a resistance heating element with 6 micrometers [in thickness], and a width of face of 10mm, and an electrostatic electrode inside.
[0137] (5) Next, after grinding the plate obtained by (4) by the diamond wheel, the mask was laid and the closed-end hole for a thermocouple (diameter: 1.2mm, depth:2.0mm) was prepared in the front face by the blasting processing by SiC etc.
[0138] (6) A part of through tube further for through holes was scooped out, it considered as the crevice, a heating reflow was carried out at 700 degrees C using the golden wax which becomes this crevice from nickel-Au, and the external terminal made from covar was connected. In addition, connection of an external terminal has the desirable structure which the base material of a tungsten supports by three points. It is because connection dependability is securable.
[0139] (7) Next, two or more thermocouples for temperature control were embedded at the closed-end hole, and manufacture of a ceramic heater (hot plate) was completed.
[0140] (Example 4 of a comparison) Although it was the same as that of an example 4, the laminating of the green sheet was carried out, without heating at 25 degrees C. According to electron microscope observation (500 times), the cross-section edge of a resistance heating element had a field perpendicular to a wafer processing side.
[0141] Using the evaluation approach (1) soak nature thermostat viewer (IR 162012-0012 by the Japanese datum company), the temperature in each location in the wafer installation side of a ceramic substrate was measured, and the temperature gradient of the minimum temperature and a maximum temperature was searched for.
[0142] (2) To 450 degrees C of adsorption power, the temperature up was carried out and it measured using the load cell (autograph by Shimadzu Corp. AGS-50).
(3) The temperature up was carried out to the thermal shock resistance of 200 degrees C, the underwater injection of this was carried out, and the existence of crack initiation was investigated. In addition, among Table 1, a crack does not generate O, but having thermal shock resistance is shown, a crack occurs and x shows that there is no thermal shock resistance.
(4) the conductor originally in a leakage current ceramic substrate insulated -- the electrical potential difference of 1kV was impressed in between, and 300-degree C leakage current was measured using the compressive test machine (Kikusui Electronics make TOS-5051) or the ultra high register (ADVANTEST CORP. make R8340).
[0143]
[Table 1]

	均熱性 (℃)	吸着力 (g／cm²)	耐熱衝撃性	リーク電流 (mA)
実施例1	4	１０００	○	4
実施例2	5	―――	○	3
実施例3	１０	―――	○	3
実施例4	4	―――	○	4
比較例1	8	８００	×	8
比較例2	１０	―――	×	8
比較例3	２０	―――	×	8
比較例4	8	―――	×	9

[0144] The ceramic substrate concerning examples 1-4 is very excellent in soak nature and thermal shock resistance so that more clearly than the above-mentioned table 1. Moreover, the chuck force of the electrostatic chuck concerning an example 1 is also large so that clearly also from an example 1 and the example 1 of a comparison.

[0145]

[Effect of the Invention] As mentioned above, as explained, the chuck force also becomes large, when the ceramic substrate of the invention in this application is excellent in soak nature and thermal shock resistance and the above-mentioned ceramic substrate is used as an electrostatic chuck.

[Translation done.]